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TEST CENTER, INC.

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President

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digital HDTV Grand Alliance System

from

AT&T
David Sarnoff Research Center
General Instrument Corporation
Massachusetts Institute of Technology
North American Philips Corporation
Thomson Consumer Electronics
Zenith Electronics Corporation

Record of Test Results

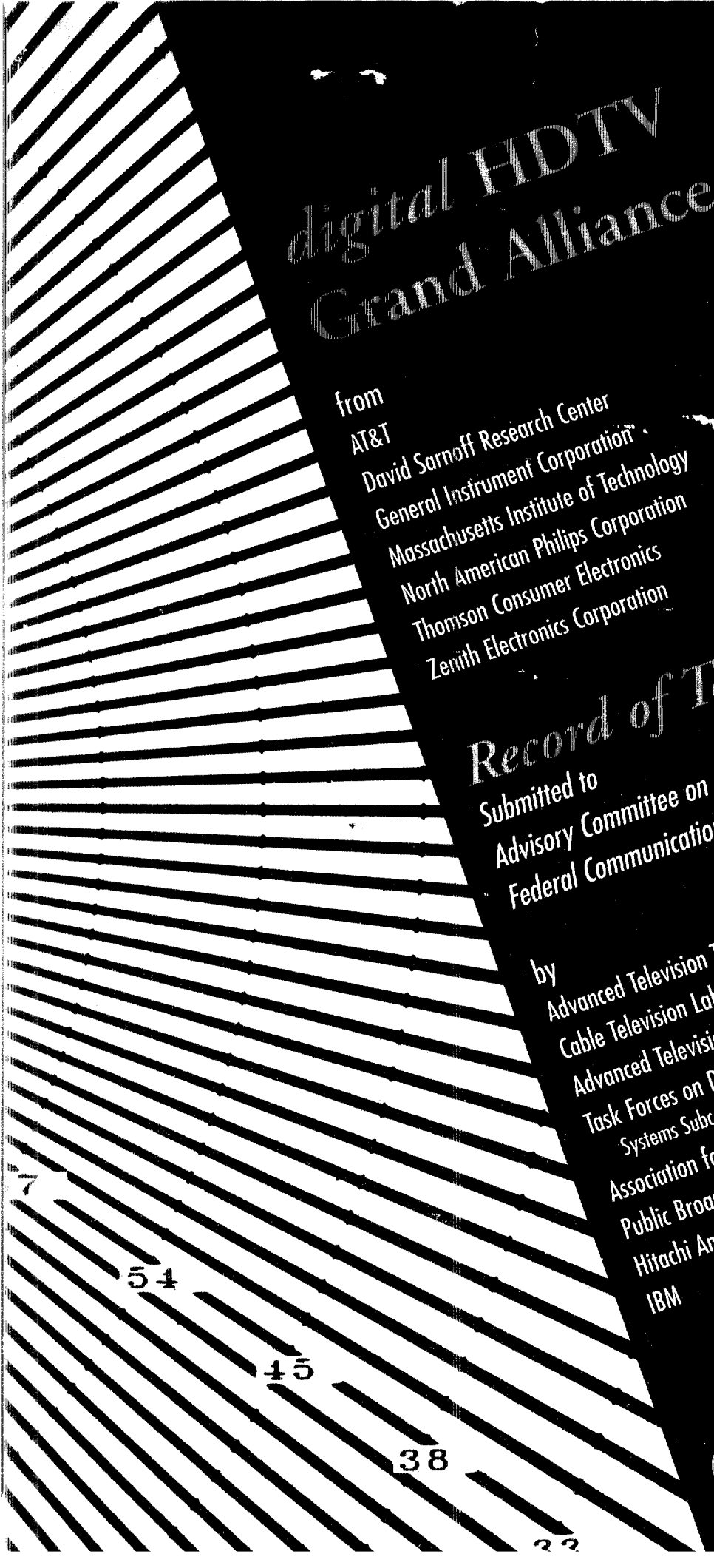
Submitted to

Advisory Committee on Advanced Television Service
Federal Communications Commission

by

Advanced Television Test Center, Inc.
Cable Television Laboratories, Inc.
Advanced Television Evaluation Laboratory, CRC
Task Forces on Digital Specific Tests, Audio & Field Tests
Systems Subcommittee/Working Party 2, ACATS
Association for Maximum Service Television
Public Broadcasting Service
Hitachi America, Ltd.
IBM

October 1995



Dedication

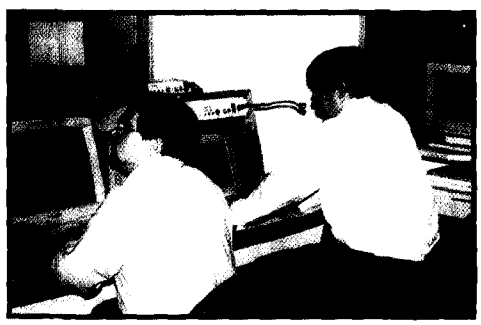
By acclamation of those involved in the testing reported here,
this volume is dedicated to the

"Texas Sign Dude"
Jon McDonald
Producer, HD VISION, Inc. (Irving, Texas)

whose performance in the most frequently used test image
(official name "Co-channel" M14)
was captured at the HDTV studios of
Captain New York (David Niles, *President*) in January 1991.

Advanced Television Test Center (ATTC)

Bruce Miller (PBS)



James Snyder, Chuck Lippmeier

Thomas Hankinson (Capital Cities/ABC), Anthony Serafini (FCC), William Calder (CBS)

Alan Godber, Thomas Gurley, Stanley Salamon

Christopher Knechtel

Robert Plonka (Harris Corporation), Dennis Wallace

Lanny Nass

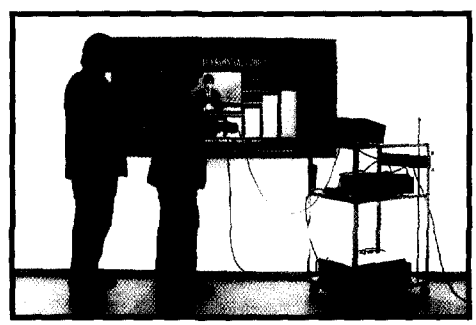
Walter Husak, Carole Chambers

James Powers (FCC), Victor Tawil (MSTV), William Inglis (FCC)

Advanced Television Evaluation Laboratory (ATEL)

(Standing, l-r): Philip Corriveau, Metin Akgun, Susan Van Dusen,

John McDonald, "Texas Sign Dude"

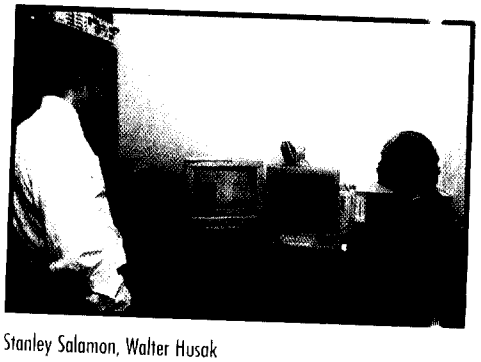


Ron Renaud, Robert Leafloor

(Seated foreground, l-r): William Zou (PBS), George Hanover [illegible] John Henderson (Hitachi), Robert Bromery (FCC), William [illegible]

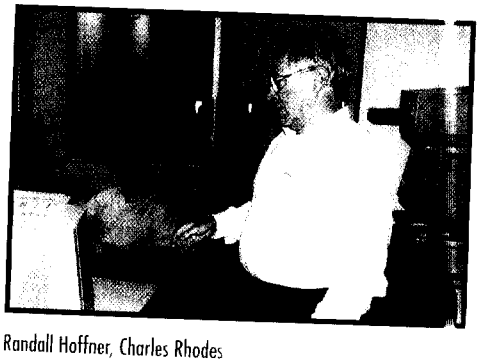
(Rear l-r). Gary Sgrignoli (Zenith), Alan Godber, Peter Fannon, Chuck Lippmeier, Thomas Gurley

With the field truck (l-r): Schettig, Peyton Hines, Sgrignoli, David Anthony, Densler, Bernard Eikotter, Ed Williams, Peter Kok



Stanley Salamon, Walter Husak

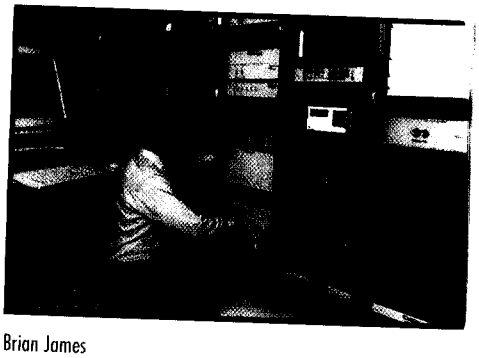
Peyton Hines (seated), Edm Williams at the transmitter site



Randall Hoffner, Charles Rhodes

In the field truck Gary Sgrigno calibrating the Grand Alliance sys tem receiver

Cable Televis[illegible] Laborator[illegible]
(CableLabs)

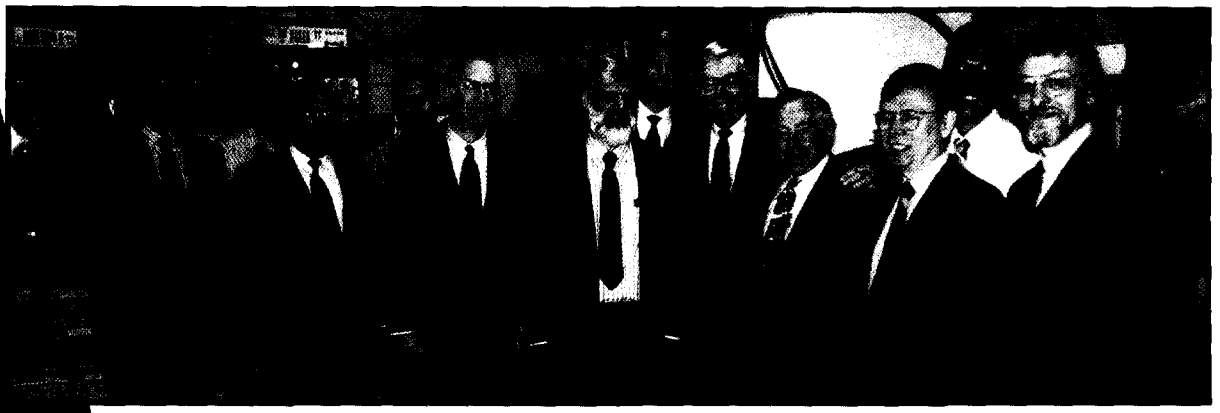


Brian James

Grand Alliance staff preparing their system hardware for test at ATTC (l-r): Gary Zimmerman (AT&T), Brian Hogstrom (GI), Victor D'Alessandro (Sarnoff), Paul Lyons (Sarnoff), Aldo Cugnini (Philips), William O'Grady (Philips), Robert Densler (Zenith), David Clune (AT&T)

AT&T

Sarnoff



April 19, 1995 — In the ATTC laboratory, with the *digital* HDTV Grand Alliance System (l-r): Peter Fannon (ATTC), Gary Zimmerman (AT&T), Victor D'Alessandro (Sarnoff), Brian James (CableLabs), Thomas Gurley (ATTC), Richard Citta (Zenith), Paul Misener (ACATS), Richard Wiley (Chairman, ACATS), Charles Rhodes (ATTC), William O'Grady (Philips), Robert Densler (Zenith), Alan Godber (ATTC)

GI General Instrument

MIT

July 18, 1995 — Celebrating completion of testing are Test Center and Grand Alliance staff (seated, l-r): Robert Rast (GI), Christopher Knechtel, Charles Rhodes; and (standing, l-r): Walter Husak, Joseph Widoff, Janet Martin, Alan Godber, Carole Chambers, Siu Wai Wu (Sarnoff), Richard Citta (Zenith), Thomas Gurley, Terry Smith (Sarnoff), Chuck Lippmeier, Richard Bunting (Sarnoff), Gary Zimmerman (AT&T), William O'Grady (Philips), Aldo Cugnini (Philips), Robert Densler (Zenith), Lanny Nass, Dennis Wallace, Peter Fannon, Brian James (CableLabs), Stanley Salamon

PHILIPS

THOMSON

October 31, 1995 — The Technical Subgroup (ACATS) marks adoption of its Final Technical Report, based on two and one-half years of analysis and tests of the Grand Alliance system, with 26 (of its 36) members and international observers. Seated (l-r): Richard Wiley (Chair, ACATS), Joseph Flaherty (Subgroup Co-Chair; CBS). Standing (l-r): Alex Felker (Time Warner Telecommunications), Peter Smith (NBC), Kenneth Davies (CBC; SMPTE); Mark Richer (PBS), Carol Darling (ABSOC, Canada), Victor Rojas (Televisa, Mexico), Reggie Gilliam (IBEW), John Henderson (Hitachi), Robert Hopkins (ATSC), Howard Miller (PBS), Robert Bromery (FCC), Branko Gerovac (MIT), Robert Sanderson (Kodak), Paul Misener (ACATS Secretary; Wiley, Rein & Fielding), Renville McMann (consultant), Victor Tawil (MSTV), Craig Tanner (TeleTV), Brian James (CableLabs), Peter Fannon (ATTC), Laurence Thorpe (Sony), Richard Prodan (CableLabs), Birney Dayton

ZENITH

digital HDTV
Grand Alliance System

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Task Forces on Digital-Specific Tests, Audio & Field Tests

Association for Maximum Service Television

Public Broadcasting Service

Hitachi America, Ltd.

IBM

October 1995

Record of Test Results
on
digital HDTV Grand Alliance System

TABLE OF CONTENTS

Comments by the Grand Alliance on the test results are included as separate sections of Parts I, II, III, and V. In Part IV, the comments are incorporated test by test.

Part I

Record of Test Results

for

digital HDTV
Grand Alliance System

from

Transmission & Objective Tests

Conducted by

Advanced Television Test Center
(April 19 - July 21, 1995)

1330 Braddock Place, Suite 200 · Alexandria, Virginia 22314-1650 · (703) 739-2850

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The Test Center and its staff are grateful to the representatives of the **Grand Alliance** member organizations, who supported their system during this testing. They were very helpful in completing the testing, which involved many new and novel tests and techniques, and in managing the test process in order to maintain the demanding schedule for the work.

This includes individuals in the **Grand Alliance Technical Oversight Group** who provided coordination and policy support:

• Carlo Basile *(Philips)* • Bill Beyers *(Thomson)* • Wayne Luplow *(Zenith)* • Ralph Cerbone *(AT&T)* • Jae Lim *(MIT)* • Robert Rast *(General Instrument)* • Glenn Reitmeier *(Sarnoff).*

In particular, ATTC staff appreciated the cooperation and advice from the **Grand Alliance Technical Staff** on site at the Test Center during the test period:

• Bhavesh Bhatt *(Sarnoff)* • Wayne Bretl *(Zenith)* • Kevin Bridgewater *(Thomson)* • Richard Bunting *(Sarnoff)* • Richard Chen *(Philips)* • Phillip Cianei *(Philips)* • Richard Citta *(Zenith)* • David Clune *(AT&T)* • Naresh Coppisetti *(Philips)* • Aldo Cugnini *(Philips)* • Victor D'Alessandro *(Sarnoff)* • John Dean *(Philips)* • Robert Densler *(Zenith)* • Henry Derovanessian *(GI)* • David Edwards *(GI)* • Jacob George *(Zenith)* • Paul Hearty *(GI)* • Brian Hogstrom *(GI)* • Harry Kern *(Sarnoff)* • Paul Lyons *(Sarnoff)* •John Mailhot *(AT&T)* • Lowell Moorhead *(Sarnoff)* • William O'Grady *(Philips)* • Leif Otto *(Zenith)* • Jeremy Pollack *(Sarnoff)* • Steven Pruss *(Sarnoff)* • Gary Sgrignoli *(Zenith)* • Terry Smith *(Sarnoff)* • Frank Templin *(Zenith)* • Kent Terry *(Dolby)* • David Williams *(Zenith)* • David Willming *(Zenith)* • Allen Wu *(GI)* • Siu Wai Wu *(AT&T)* • Gary Zimmerman *(AT&T).*

* * *

ATTC also wishes to give special thanks to the following individuals—and their organizations—who served without compensation and for hours on end as **Expert Observers.**

They include the members of the **Task Force on Digital-Specific Tests, SS/WP-2:**

• John G.N. Henderson, Chairman *(Hitachi America)* • Robert Bromery *(FCC)* • George Hanover *(EIA)* • William Inglis *(FCC)* • William Zou *(PBS)*

They also include the **Expert Viewers and Listeners** on loan from their organizations:

• J. Talmage Ball *(Bonneville International)* • Robert Bromery *(FCC)* • William Calder *(CBS)* • Lynn Claudy *(NAB)* • Jules Cohen *(Jules Cohen & Associates)* • Robert Dickinson *(Dovetail Surveys, Inc.)* • David Felland *(WMVS-TV, Milwaukee)* • Thomas Hankinson *(Capital Cities/ ABC)* • George Harenberg *(FCC)* • William Inglis *(FCC)* • Ralph Justus *(EIA)* • Chiharu Kamise *(Fuji Television, Tokyo)* • Edward Krom *(e-on Corporation)* • Wilson LaFollette *(Cohen, Dippell & Everist)* • Suzanne Mesnick *(NPR)* • Cynthia Nila *(NTIA)* • Edward Poulin *(Consultant)* • James Powers *(FCC)* • John Reiser *(FCC)* • Anthony Serafini *(FCC)* • Neil Shade *(Acoustical Design)* • Joseph Snelson *(Meredith Corporation)* • Victor Tawil *(MSTV)* • John Watson *(Group W)* • Werner Wedam *(Sharp Electronics)* • Edmund Williams *(PBS)* • William Zou *(PBS).*

* * *

Special thanks—and congratulations—go to the staffs of ATTC's sister **Laboratories** for their terrific assistance, advice and patience: **Advanced Television Evaluation Laboratory** (Ottawa, Canada), directed by Metin Akgun and Robert Leafloor; and, **Cable Television Laboratories** (with staff and equipment at ATTC and based in Louisville, Colorado), directed by Craig Tanner, Richard Prodan and Brian James.

On behalf of the Members and sponsors of the Test Center, thanks are also due many companies and individuals whose **Contributions of Equipment and Time** made much of this testing possible. ATTC wishes to recognize the following:

• Alesis Corporation (loan of digital audio equipment) • BBC (David Meares—design of live camera set) • Boonton Electronics (Gupreet Kohli—loan of power measuring devices) • BTS (Hermann Naber—loan of HDTV CCD camera) • Century Computing (Carl Cornwell—PIXAR software programming services) • Cipher Digital (Robert Tulloh—loan of CDI 750 Time Code Reader) • Dolby (Craig Todd– -audio design, equipment and test materials support) • Harris Corporation (Robert Plonka—development, calibration and maintenance of RF Test Bed; Robert Weirather—RF equipment support) • Hewlett-Packard (Greg Simon—loan of ghost simulator) • Hitachi (Masanori Ogino—assistance in optimizing the projection display for critical viewing of HDTV) • Bronwen Jones—test materials support • mci, Inc./PESA (Thomas Vaughn—prototype HDTV transmitter for demonstration) • National Instruments (hardware and Labview software support) • NBC (construction of two sets for live camera scenes) •Panasonic (James Gaspar—test materials support) • PBS (Bruce Miller—engineering management services) • Scala Electronic Corporation (Ellis Feinstein—loan of antenna utilized in cross-polarization study) • Sony (Kevin Basquill—HDD-1000 videotape recorder maintenance) • Stanford Research Systems (David Ames—loan of the LORAN frequency synthesizer) • Tektronix (Philip Crosby and Ajay Luthra—design, construction and support of Format Converters) • Fred Van Roessel—consultation on the HDTV CCD camera.

* * *

Finally, the Test Center staff wish to thank those who are **FCC Advisory Committee** (ACATS), FCC, cooperating laboratories, and other leaders with roles closely associated with this testing work, for their guidance, assistance and encouragement:

• Richard E. Wiley *(Chairman, ACATS)* • Paul Misener *(Secretary, ACATS)* • Joseph Flaherty *(Co-Chairman, Technical Subgroup)* • Irwin Dorros *(Co-Chairman, Technical Subgroup)* • Mark Richer *(Chairman, SS/WP-2)* • James Gaspar *(Chairman, PS/WP-6)* • Bronwen Jones *(Vice-Chairman, PS/WP-6)* • Jules Cohen *(Vice-Chairman, PS/WP-3)* • Victor Tawil *(Member, PS/WP-3 and Technical Subgroup)* • Richard Smith *(Chief, OET, FCC)* • Bruce Franca *(OET, FCC)* • Alan Stillwell *(OET, FCC)* • William Hassinger *(MMB, FCC)* • Rita McDonald *(WTB, FCC)* • Robert Niles *(Chairman, ATTC Technical Committee; Capital Cities/ ABC).*

* * *

The **Advanced Television Test Center (ATTC)** is a private, non-profit enterprise formed in 1988 by a coalition of broadcasting companies and industry organizations in order to test advanced television systems for a new, national broadcast TV standard. It is financed by its Members, with the support of individual and group-owned television stations. Its **Members** are • Capital Cities/ABC, Inc. • CBS Inc. • NBC, Inc. • Public Broadcasting Service (PBS) • Association of Independent Television Stations (INTV) • Association for Maximum Service Television (MSTV) • Electronic Industries Association (EIA) and • National Association of Broadcasters (NAB). In addition, Fox Broadcasting Company is an Associate Member.

For the testing of the ***digital*** **HDTV Grand Alliance System**, ATTC staff included: • Carole A. Chambers, *Data Specialist* • Peter M. Fannon, *President* • Alan S. Godber, *Test Administrator* • Thomas M. Gurley, *Director of Testing* • Randall N. Hoffner, *Manager, Technical Operations* • Walter J. Husak, *Senior Technician* • Christopher M. Knechtel, *Videotape Editor/Technician* • Charles S. Lippmeier, *Manager, Computer Systems Engineering* • Janet A. Martin, *Viewer Coordinator & Executive Secretary* • E. Lanny Nass, *Manager, Facilities & Equipment* • Norma J. Parrish, *Executive Secretary* • Charles W. Rhodes, *Chief Scientist* • Stanley J. Salamon, *Software Engineer* • James P. Snyder, *Videotape Editor* • Joseph A. Strouse, *Member Technical Staff* • Clarece P. Thame, *Office Manager & Staff Assistant* • Dennis W. Wallace, *Member Technical Staff, RF Systems* • Joseph W[illegible] *President, Finance & Administration*

Section 1.

INTRODUCTION

This Report contains the results of tests conducted by the Advanced Television Test Center (ATTC) on the ***digital* HDTV Grand Alliance System** during the period April 19 - July 21, 1995.

The testing was undertaken by ATTC in support of the work of the Advisory Committee on Advanced Television Service of the Federal Communications Commission (FCC Advisory Committee). It is the FCC Advisory Committee which will evaluate these results for the purpose of making recommendations in keeping with its charter.

It also contains comments by the Grand Alliance on these test results (see *Section 15*).

The results of additional tests on the Grand Alliance system are provided elsewhere by:

- Task Force on Digital Specific Tests (SS/WP-2)
- Cable Television Laboratories (CableLabs)
- Advanced Television Evaluation Laboratory/Communications Research Centre (ATEL/CRC)
- Task Force on Audio (SS/WP-2)
- Hitachi America Ltd.
- IBM
- Task Force on Field Testing (SS/WP-2)

* * *

The organization of this Report is as follows:

1.1. ATTC Test Results

Sections 2-12 parallel those in the Test Plan document (see "Test Plan", below). While a brief description of the purpose of each test is included at the beginning of each Section, the Test Plan itself is not reprinted here. ***It is intended that the Test Plan be used in conjunction with this Report in order to understand the test results.***

All the tests in the Test Plan are listed in *Part VI* of the *Record of Test Results*. Using the Matrix is the best way to find a particular test or related tests, or to review the contents of the Test Plan.

The form of the results of individual tests in this Report is as specified in the Test Plan, *e.g.* in decibels, desired (D) and undesired (U) signal levels, waveform or video monitor photographs, spectrum analyzer plots, etc. However, ATTC has also assembled many results into tabular and summary form in order to facilitate use of these data. Also, any Expert Observer comments for a test are associated with the results of that test.

Section 3 reports interference test results, among other things. Please note that the Report is not yet complete on the matter of the "color beat" observed in the case of Upper Adjacent ATV interference into NTSC. Comments by the Grand Alliance, as requested by the Chairman of SS/WP-2, will be included upon receipt.

Section 9 is reserved for the addition of results from the "Interoperability" tests, which are not completed, pending work by the Grand Alliance on "data tapes" to be used in these tests.

ATTC maintains video and audio tape records of the Grand Alliance system's performance under various interference and impairment conditions, as well as for its basic (*i.e.* unimpaired) video and audio quality. As per the Test Plan, these tapes provided the mechanism for conducting certain tests at ATTC, ATEL and, in part, CableLabs, Hitachi, and IBM. These tape recordings are available to the FCC Advisory Committee for review, as appropriate, although it should be noted that most of the videotapes can only be viewed with the use of specialized equipment. (Tapes of test results from the earlier HDTV systems, tested in 1991-92 for the FCC Advisory Committee, have also been retained; so it is possible to compare changes in performance. Indeed, some of this was done by the Task Force on Digital Specific Tests.)

In addition, ATTC retains an archive of photographs, operations logs, daily "signature tests", and other laboratory notes and equipment verification records. These are available, as appropriate, for review by the FCC Advisory Committee.

Section 13 contains background on ATTC actions in preparing video and audio tapes for use by others. The video tape information is provided as background to the record of test results from ATEL. The audio tape information is provided as background to the record of test results from NCTA.

1.2. Grand Alliance Comments on Test Results

The comments of the Grand Alliance about these test results are included in *Section 15*. During the test period, the Grand Alliance reviewed the test results with ATTC and agreed that they were complete and satisfactorily documented (see *Section 14*).

1.3. Grand Alliance System Documentation

Information about the *digital* HDTV Grand Alliance System is contained in the documentation provided by the Grand Alliance to the FCC Advisory Committee. It is sizable and available in the public record; therefore, it is not reproduced in this Report (see "Grand Alliance HDTV System Specification," December 7, 1994, as amended).

In *Section 14* of this Report, however, there is further information provided by the Grand Alliance during or after the course of testing, or as specifically requested by the Chairman of SS/WP-2, for the purpose of documenting something encountered in the course of testing. Sometimes this information is necessary to the understanding of why certain tests were conducted as they were.

The Grand Alliance certified to ATTC that its system delivered to the Test Center in two stages—on March 31, 1995 (transmission, transport subsystems), and May 17, 1995 (video encoding, compression)—was the system approved for testing by the FCC Advisory Committee's Technical Subgroup (December 7, 1994). On July 18, 1995, the Grand Alliance advised ATTC of one variance (*i.e.* sync level) between the system tested and the system as

approved for testing (see *Section 14*). In keeping with the FCC Advisory Committee's Test Management Plan, the Grand Alliance also certified that its system was not changed in any way, only maintained and repaired as necessary, while at the Test Center. Information about the operation, maintenance and/or repair of the Grand Alliance system and of ATTC equipment during the course of the testing period is contained in a "Daily Plant and ATV System Certification Log" which was kept by, and is on file with, the Grand Alliance and ATTC.

1.4. Test Plan

ATTC conducted its tests in accordance with the requirements and test procedures developed and approved by the FCC Advisory Committee. These include the relevant portions of the "Grand Alliance System Test Procedures" (SSWP2-1306, "Test Plan"), and the "Test Management Plan" (SSWP2-0124). Because these documents are sizable and are in the FCC Advisory Committee's public record, they are not reproduced in this Report.

The Test Plan used by ATTC was approved by the FCC Advisory Committee as of March 24, 1995. Since that time, including during the course of the Grand Alliance test period, various interpretations of or other actions on the Test Plan were taken by the designated specialist group—Systems Subcommittee Working Party 2, System Evaluation and Testing (SS/WP-2)—and are included in *Section 14* and in the records of SS/WP-2.

Section 2.

SYSTEM PERFORMANCE VERIFICATION

2.1. Introduction

A series of "signature" tests were employed by ATTC to detect any changes in performance of the Grand Alliance system during the testing period.

Each day of the testing period, signature tests were conducted in the morning, before testing began, and at the end of the testing day, after all tests were completed. An additional signature test was frequently conducted at the lunch break, at the discretion of ATTC. Each morning when these signature tests were conducted, ATTC staff and the proponent jointly reviewed the results for consistent operation of the system. When the proponent was satisfied that the Grand Alliance system was functioning correctly, a proponent representative and an ATTC representative signed and dated each of the signature photos and plots. The signature documentation obtained at the lunch break and at the end of the day was reviewed and signed by ATTC staff.

Indeed, ATTC did, from time to time, observe minor performance changes. For example, as discussed below, chrominance transient response was found to vary. Also, the BER threshold for random noise sometimes changed. This knowledge was communicated to the proponent. In all cases, these observations were logged and the signature test documentation was archived.

Between May 17, 1995, when the interference and impairment tests had been completed, and May 22, 1995, when the quality-related tests were begun, the Grand Alliance installed—and ATTC conducted interface checks and dry runs on—modifications to the Grand Alliance system to optimize the video performance. This two-phase approach to the testing, and the extent of the mid-course modifications, had been approved by the laboratories and by SS/WP-2 prior to the start of any testing. Aside from these approved modifications, and occasional repairs that involved swapping modules with identical spares, there is no evidence that any other changes were made to the system during the course of testing.

2.2. Baseband Video Performance

Signature tests of baseband video performance were made using the test pattern described in *Section I-2.2.2* of the Test Plan. Waveform photographs, which have been archived by ATTC, were obtained of the Red, Green, and Blue video output signals from the Grand Alliance system.

One of the features of the test pattern is a set of "chroma ramps". The amplitude of each ramp is 700 mV. To permit assessment of headroom, there is a pulse during part of the horizontal blanking period that extends downward by 50 mV. At the end of the ramp, within the active line time, there is another pulse extending upward by 64 mV. At the output of the Grand Alliance system, these pulses are clipped entirely. Therefore, the dynamic range of the system is 700 mV, with hard limiting at black and nominal white levels. The Grand Alliance confirmed to ATTC that the RGB signals are digitized in 10-bit linear PCM with black = 64 and white = 940. The digital signals are then hard limited so that values less than 64 or greater than 940 do not exist in the signal.

The Grand Alliance system includes horizontal peaking, which was in operation at all times, except while the objective tests of image resolution (*Section 5*) and transient response (*Section 7*) were being conducted. One effect of the peaking was variation of the peak amplitude of the various sine-squared pulses in one of the signature tests, but only in the 720P format. The pulses were of equal amplitude when the peaking was switched off during the objective tests. Such position-dependent amplitude variations may cause scintillation of moving transients.

The peaking was documented by additional signature tests whenever objective testing required that it be switched off and on. A video swept-frequency test signal was introduced, 2 dB below 700 mV p-p and on a pedestal. When the swept frequency response was examined on an oscilloscope, several anomalies were noted. These anomalies were also observed on a color monitor when the swept-frequency test signal was displayed. The Test Center requested that the Grand Alliance furnish an explanation of these anomalies. Their response may be found in a letter from Kiran S. Challapali (Philips) to Charles Rhodes (ATTC), reproduced in *Section 14*.

The Test Center also noted that the transient response of the chrominance channels varied considerably from day to day in our signature tests. This issue is discussed in a memo from Siu-Wai Wu (AT&T) to Charles Rhodes (ATTC), reproduced in *Section 14*. Sometimes there was very little ringing before the transition; at other times, there were several cycles before the transition. Ringing after the transition also was subject to variation. From time to time, the Grand Alliance system had to be reset. It is believed that the system exhibits somewhat different transient behavior after being reset. Members of the Grand Alliance team suggested to ATTC staff that perhaps not all circuits are always fully reset.

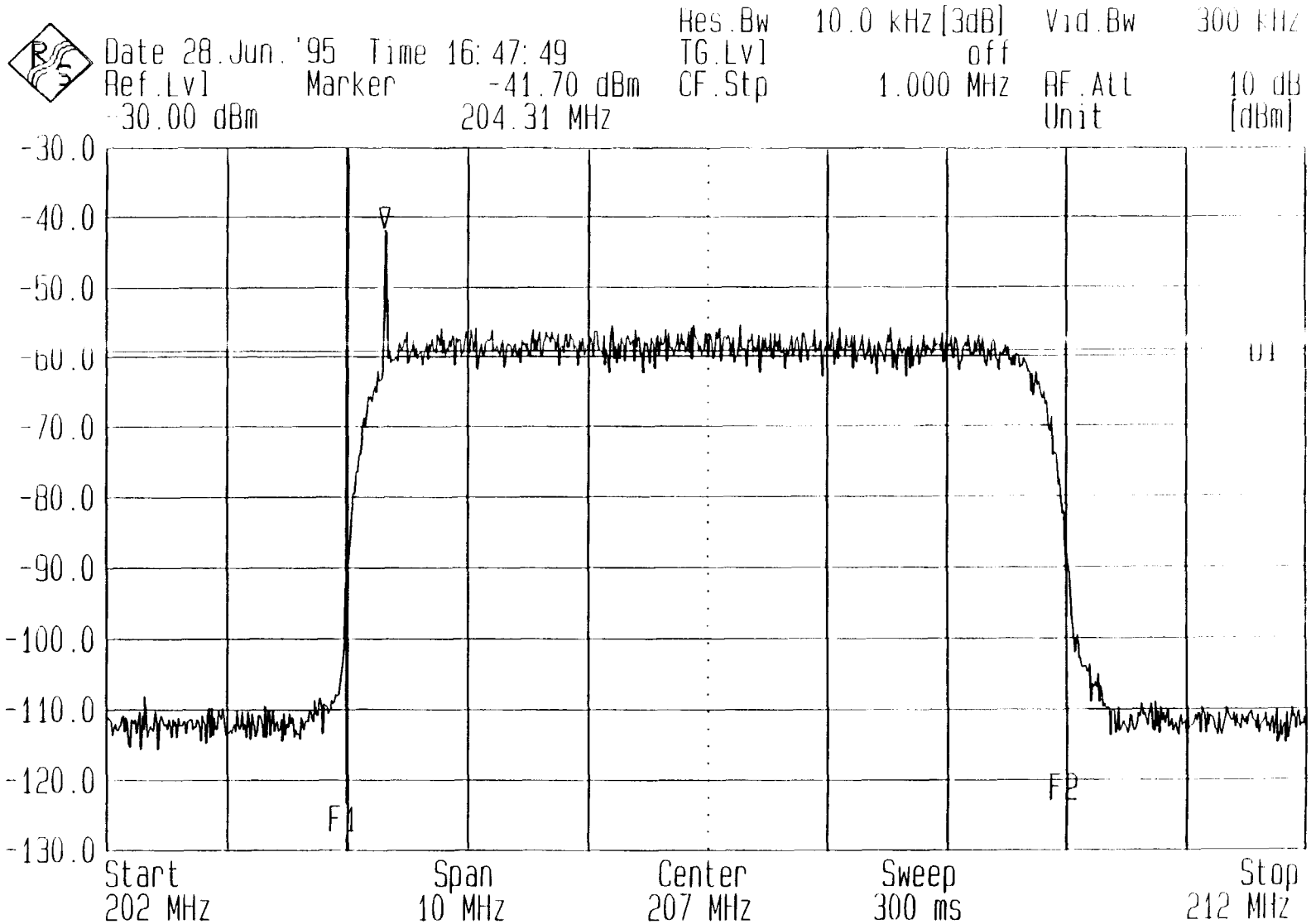
2.3. Transmitted Signal Spectrum

The spectrum of the Grand Alliance signal was measured in accordance with *Section I-2.3* of the Test Procedures. The measurement was made on the RF signal resulting from upconversion of the IF signal provided by the Grand Alliance encoder to the Desired channel (*e.g.*, Channel 12), the upconversion taking place in the ATTC RF Test Bed.

A typical spectrum plot is reproduced as Figure 2-1. Each spectrum plot is annotated with all relevant parameter values, as well as the date and time at which it was made. The 3-dB bandwidth of the Grand Alliance signal spectrum may be determined using these plots. The center frequency of each plot is the center frequency of the Desired channel (207 MHz for Channel 12). The horizontal scale of each plot is 1 MHz per division.

2.4. BER Threshold for Random Noise

The threshold for random noise impairment was routinely verified by applying a Strong level (-28 dBm) signal, with random noise at D/U ratio of approximately 15.19 dB (the measured TOV for the official Test #58). Three consecutive 20-second BER measurements were taken at this level. These measurements were compared with measurements taken previously to determine whether a performance change had occurred. Sometimes changes were noted, and the Grand Alliance was given the opportunity to reset or repair the system before testing was resumed.



START OF DAY SIGNATURE TEST D1= -59.12 dBM DWW
VHF RFTB SAMPLE IN TOC

Random Noise into ATV Signature Test
D level: -28.0; **D/U Ratio:** 15.07
BER Readings: 1) 1.72E-6
2) 1.71E-6
3) 1.61E-6

Figure 2-1

Section 3.

LABORATORY TESTING OF TERRESTRIAL TRANSMISSION ISSUES

Testing of transmission issues was conducted in accordance with the impairment and interference test procedures described in Section I-3 of the Grand Alliance System Test Procedures document. The results are presented here in the same order as the procedures appear in the referenced document. Impairment testing determined the susceptibility of a "Desired" signal, provided by the Grand Alliance system, to various transmission impairments that were simulated by the ATTC RF Test Bed. The impairments included random noise, impulse noise, and static and dynamic multipath. Interference testing involved two RF signals—a "Desired" signal and an "Undesired" signal. The signal provided by the Grand Alliance encoder was tested as both Desired and Undesired, with respect to both an NTSC signal and another, identical, Grand Alliance signal. In addition, interference from radio services (discrete frequencies) was simulated by the RF Test Bed. For all tests in which the ATV signal was Desired, interference thresholds were determined by Bit Error Rate (BER) measurement on pseudorandom data transmitted through the Grand Alliance system. For a subset of these tests, the thresholds were confirmed by at least three expert observers viewing the output of the Grand Alliance receiver on a large-screen video projection display. When NTSC was the Desired signal, a bank of 24 off-the-shelf consumer NTSC receivers was viewed by three expert observers.

Using methods detailed in the Video Subjective Test Procedures (Part III of the referenced document), the panels of expert observers determined the threshold of visibility (TOV) and, as required, the point of unusability (POU) and intermediate ranging levels that were videotaped for subsequent non-expert subjective assessment of ATV-into-NTSC interference. The four intermediate levels are designated TOV+1 through TOV+4. Details of the videotape preparation are found in *Section 15*. The results of the non-expert subjective testing by the Advanced Television Evaluation Laboratory (ATEL) are documented separately (see *Part III*).

The test results in this section cover only the effects of impairment and interference upon the video signals. The susceptibility to interference of the BTSC audio portion of an NTSC transmission is reported in *Section 4*.

The ATTC RF Test Bed was designed to provide Undesired signal levels consistent those which industry experts have told us represent the maximum levels found in practice in the field. In some tests, the maximum power level was reached before the data point required by the Test Plan (e.g., TOV, CCIR3, POU) could be found. In these cases, the "less than" ("<") symbol appears in the data table preceding the D/U ratio corresponding to the maximum Undesired signal level.

3.1. Confirmation of Relationship between ATV "TOV" Using BER Method and Visual TOV

The Test Plan specifies that the TOV for all ATV interference and impairment tests be determined using BER measurement on pseudorandom data transmitted through the Grand Alliance system. For a subset of 11 tests, expert observers were required to confirm the BER TOV by viewing a picture and using a visual TOV procedure. It was expected that the visual TOV and the BER TOV would not differ by more than 0.5 dB. It was also expected that the threshold characteristic for any test, over a range of ±0.5 dB about the threshold, would conform to the characteristic of either random noise or impulse noise.

A comparison of the visual and BER TOVs for the tests conducted both ways is presented in Table 3-1 below. For both adjacent channel tests (ATTC Tests #4 and 11) at the Strong Desired signal level, the TOV could not be achieved at the maximum available Undesired signal level. Therefore, additional comparison tests were conducted at the Moderate Desired signal level. Note that for all tests, except ATTC Test #290, the two TOVs were within 0.5 dB of each other. This test exhibited a further anomaly in the subjective (visual) portion, in that the system failed to acquire at the TOV level. For 10 of the 11 tests in which the BER TOV was found, additional BER measurements were obtained at impairment levels 0.25 dB and 0.5 dB above and below the TOV level, in order to determine the threshold characteristic. (The additional measurements were inadvertently not taken for Test #4 at Moderate.) At each level, three consecutive 20-second measurements were taken. The results of these measurements are presented in Table 3-2.

Table 3-1

ATTC Test #	Description	Subjective Method				BER Method		
		Desired Power		Desired to Undesired Ratio (dB)		Desired Power	Desired to Undesired Ratio (dB)	
		Level	dBm	ACQ	TOV	dBm	ACQ	TOV
58	Random Noise		-27.89		15.28	-28.12	OK	15.19
127	Impulse Noise		-52.93		0.38*	-53.10	OK	0.40*
17	Co-Channel NTSC/ATV	W	-67.86		2.05	-68.10	OK	1.81
11	Lower Adjacent NTSC/ATV	S	-27.85	NT	<-22.94	-28.04	NT	<-23.18
11	Lower Adjacent NTSC/ATV	M	-52.86	OK	-44.37	-53.05	OK	-44.46
11	Lower Adjacent NTSC/ATV	W	-67.86	OK	-47.61	-68.04	OK	-47.73
4	Upper Adjacent NTSC/ATV	S	-27.85	NT	<-22.98	-28.05	NT	<-23.18
4	Upper Adjacent NTSC/ATV	M	-52.87	OK	-44.44	-53.04	OK	-44.44
4	Upper Adjacent NTSC/ATV	W	-67.86	OK	-48.54	-68.04	OK	-48.71
290	Strongest Dynamic Echo Rejection: 1.8μS in Ensemble A (0 Hz)	S	-27.86	5.40	5.00	-27.89	OK	4.20
291	Strongest Dynamic Echo Rejection: 1.8μS in Ensemble A (0.05 Hz)	S	-27.86	OK	7.85	-27.89	OK	7.60
292	Strongest Dynamic Echo Rejection: 1.8μS in Ensemble A (0.50 Hz)	S	-27.86	OK	9.00	-27.89	OK	9.10
293	Strongest Dynamic Echo Rejection: 1.8μS in Ensemble A (5 Hz)	S	-27.86	OK	12.70	-27.89	OK	12.50

*Desired signal level minus noise level relative to zero attenuation of noise.

Table 3-2

Random Noise into ATV
ATTC Test # 58
Strong Desired Signal Level

	-0.50 dB	-0.25 dB	Threshold	+0.25 dB	+0.50 dB
Desired to Undesired Ratio (dB)	14.69	14.94	15.19	15.44	15.69
Bit Error Rate	5.74E-04	3.55E-05	7.32E-07	0.00E+00	0.00E+00
	5.89E-04	3.67E-05	8.22E-07	0.00E+00	0.00E+00
	5.95E-04	3.35E-05	1.03E-06	0.00E+00	0.00E+00

Impulse Noise into ATV
ATTC Test # 127
Moderate Desired Signal Level

	+0.50 dB	+0.25 dB	Threshold	-0.25 dB	-0.50 dB
Relative noise level (dB)*	-53.00	-53.25	-53.50	-53.75	-54.00
Bit Error Rate	6.34E-06	6.20E-06	1.36E-06	2.17E-06	7.11E-07
	9.56E-06	7.06E-06	1.87E-06	1.19E-06	4.06E-07
	1.41E-05	5.42E-06	1.26E-06	1.10E-06	1.40E-07

* Noise level relative to zero attenuation of noise

Co-Channel NTSC/ATV
ATTC Test # 17
Weak Desired Signal Level

	-0.50 dB	-0.25 dB	Threshold	+0.25 dB	+0.50 dB
Desired to Undesired Ratio (dB)	1.31	1.56	1.81	2.06	2.31
Bit Error Rate	4.76E-05	9.85E-06	1.40E-06	2.10E-07	0.00E+00
	4.89E-05	1.07E-05	1.23E-06	4.61E-07	6.80E-08
	4.77E-05	1.18E-05	1.26E-06	4.00E-08	0.00E+00

Table 3-2 (Continued)

Lower Adjacent NTSC/ATV
ATTC Test # 11
Moderate Desired Signal Level

	-0.50 dB	-0.25 dB	Threshold	+0.25 dB	+0.50 dB
Desired to Undesired Ratio (dB)	-44.96	-44.71	-44.46	-44.21	-43.96
Bit Error Rate	8.13E-04	2.95E-05	2.20E-07	0.00E+00	0.00E+00
	7.95E-04	2.68E-05	6.10E-08	0.00E+00	0.00E+00
	8.43E-04	2.71E-05	9.50E-08	0.00E+00	0.00E+00

Lower Adjacent NTSC/ATV
ATTC Test # 11
Weak Desired Signal Level

	-0.50 dB	-0.25 dB	Threshold	+0.25 dB	+0.50 dB
Desired to Undesired Ratio (dB)	-48.23	-47.98	-47.73	-47.48	-47.23
Bit Error Rate	2.72E-04	2.05E-05	5.40E-07	0.00E+00	0.00E+00
	2.41E-04	1.73E-05	7.59E-07	0.00E+00	0.00E+00
	2.60E-04	1.83E-05	4.79E-07	0.00E+00	0.00E+00

Upper Adjacent NTSC/ATV
ATTC Test # 4
Moderate Desired Signal Level

	Threshold
Desired to Undesired Ratio (dB)	-44.44
Bit Error Rate	0.00E+00
	0.00E+00
	7.40E-08

Table 3-2 (Continued)

Upper Adjacent NTSC/ATV
ATTC Test # 4
Weak Desired Signal Level

	-0.50 dB	-0.25 dB	Threshold	+0.25 dB	+0.50 dB
Desired to Undesired Ratio (dB)	-49.21	-48.96	-48.71	-48.46	-48.21
Bit Error Rate	3.89E-04	3.56E-05	1.19E-06	0.00E+00	0.00E+00
	3.81E-04	3.48E-05	1.14E-06	1.00E-07	0.00E+00
	3.80E-04	4.02E-05	1.26E-06	0.00E+00	0.00E+00

Strongest Dynamic Echo Rejection: 1.8μS in Ensemble A (0 Hz)
ATTC Test # 290
Strong Desired Signal Level

	-0.50 dB	-0.20 dB	Threshold	+0.20 dB	+0.50 dB
Main Path to Variable Path Ratio (dB)	3 70	4.00	4.20	4.40	4.70
Bit Error Rate	6.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6.51E-05	1.70E-07	0.00E+00	0.00E+00	0.00E+00
	4.95E-05	4.21E-05	0.00E+00	0.00E+00	0.00E+00

Strongest Dynamic Echo Rejection: 1.8μS in Ensemble A (0.05 Hz)
ATTC Test # 291
Strong Desired Signal Level

	-0.50 dB	-0.20 dB	Threshold	+0.20 dB	+0.50 dB
Main Path to Variable Path Ratio (dB)	7.10	7.40	7.60	7.80	8.10
Bit Error Rate	3.49E-05	4.56E-07	0.00E+00	1.42E-06	0.00E+00
	3.69E-05	1.58E-06	7.90E-08	9.20E-06	0.00E+00
	5.66E-05	1.31E-04	4.74E-07	8.40E-08	0.00E+00